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Science | Sciences
Newfoundland and Labrador Region
Canadian Science Advisory Secretariat
Science Advisory Report 2013/005

WOLFFISH IN THE ATLANTIC AND ARCTIC REGIONS

Photo by Trevor Maddigan, DFO-NL Region

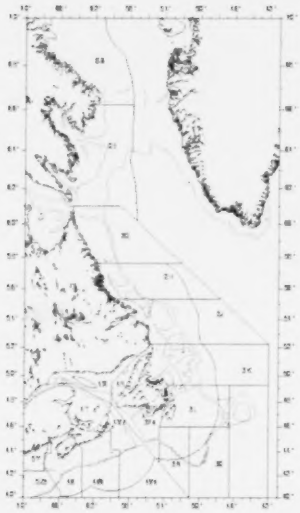

Figure 1. Map of NAFO Divisions.

Context

Three wolffish species are found in both Canadian Atlantic and Arctic waters: Anarhichas denticulatus (Northern Wolffish), Anarhichas minor (Spotted Wolffish), and Anarhichas lupus (Atlantic Wolffish).The first two species were designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2001, while Atlantic Wolffish was designated as Special Concern. Upon passage of the Species at Risk Act (SARA) in June 2003, these species were listed on Schedule 1 of SARA. A requirement under SARA is the development of a Recovery Strategy for all Extirpated, Endangered, and Threatened species, or a Management Plan for all species listed as Special Concern. As such, a joint Recovery Strategy/Management Plan was published in 2008, for the Northern, Spotted, and Atlantic Wolffish.

Under Section 46 of SARA, the Minister of Fisheries and Oceans Canada (DFO) is required to report on the implementation of a Recovery Strategy for a species at risk, and on the progress towards meeting recovery objectives. Therefore, DFO implemented Progress Reports that cover five-year periods: the first Report is due on the fifth anniversary of the date when the Recovery Strategy was placed on the SARA Public Registry, and at subsequent five-year periods until population and distribution objectives for the species at risk have been achieved, or the species' recovery is no longer feasible. In addition, under SARA, there are monitoring and reporting requirements for the implementation of Management Plans (s.72 SARA) and Action Plans (s.55 SARA).

COSEWIC recently (Nov. 2012) re-assessed the status of the three wolffish species, and upheld the designations of Threatened for Northern Wolffish and Spotted Wolffish, and Special Concern for Atlantic Wolffish.

This Science Advisory Report was generated by the 23-24 January, 2013, assessment of Northern, Spotted, and Atlantic Wolffish related to population status, life history, and habitat. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule.

Canada

SUMMARY

- Northern Wolffish and Spotted Wolffish remain Threatened under the *Species at Risk Act* (SARA), while Atlantic Wolffish is still of Special Concern.
- Northern Wolffish were described as "fish specialists" (piscivores), Spotted Wolffish as "echinoderm specialists" (benthivores), and Atlantic Wolffish as "mollusc specialists" (benthivores).
- Northern Wolffish in Newfoundland and Labrador waters appear to comprise at least two distinguishable groups. Atlantic Wolffish also appear to comprise two distinguishable groups.
- In the Gulf of St. Lawrence, dissolved oxygen levels where some wolffish are found were shown to reduce growth rates of Spotted Wolffish in laboratory studies.
- SARA logbook data from fishers aboard >35 foot commercial vessels fishing in Canada's Exclusive Economic Zone (EEZ) indicated that a large percentage of wolffish were released alive in 2005-2010.
- In recent years, there was a very gradual increase in catch rates of Northern Wolffish during the DFO spring research survey in Northwest Atlantic Fisheries Organization (NAFO) Div. 3LNO, and during the fall survey in Div. 2J3K and Div. 3LNO.
- In recent years, during the DFO fall research survey in Div. 2J3K and Div. 3LNO, catch rates of Spotted Wolffish were generally increasing. However, during the spring survey, following a general increase in Div. 3LNO over 1995-2006, catches of this species have been declining.
- Annual mean number per tow for Atlantic Wolffish in the DFO-Maritimes Region research surveys has declined since 1990. Area of occupancy (AO) for Atlantic Wolffish has exhibited a steady decline: from approximately 60,000 km^2 to about 10,000 km^2 in 2012.

INTRODUCTION

Wolffish (family Anarhichadidae) inhabit a wide range of northern latitudes and depths in the Atlantic and Pacific Oceans (Scott and Scott 1988). Three wolffish species are found in both Canadian Atlantic and Arctic waters: *Anarhichas denticulatus* (Northern Wolffish), *Anarhichas minor* (Spotted Wolffish), and *Anarhichas lupus* (Atlantic Wolffish). The first two species were designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2001; while Atlantic Wolffish was designated as Special Concern (Kulka et al. 2004). In September of 2010, a regional review of available data was presented (Dutil et al. 2011; Simon et al. 2012; Simpson et al. 2012). In November 2012, COSEWIC re-evaluated the status of wolffish in Canada, and concluded that, despite signs of population recovery, Northern Wolffish and Spotted Wolffish remain designated as Threatened, while Atlantic Wolffish is still designated of Special Concern. As there was no change in the COSEWIC designations, the status of these species under the *Species at Risk Act* (SARA) remains unchanged.

As part of the federal SARA process, Fisheries and Oceans Canada (DFO) is required to report on the implementation of the Recovery Strategy (Kulka et al. 2007) for wolffish, and on the

progress towards meeting recovery objectives. The general intent of this paper is to provide scientific information to support a review of Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish under Sections 46, 55, and 72 of Canada's SARA.

Species Biology

General species biology has been described at length in previous research documents (Dutil et al. 2011; Ouellet et al. 2011; Simon et al. 2012; Simpson et al. 2012), and is not repeated here. Instead, new biological information is provided below; under DFO's mandate to support the review of these three wolffish species.

Diet

Food and feeding habits of Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish in Newfoundland and Labrador (NL) continental shelf waters were examined. The most important prey groups were: pelagic and benthic fishes for Northern Wolffish; shrimp and echinoderms for Spotted Wolffish; and crabs and echinoderms for Atlantic Wolffish. Diet overlap was highest between Spotted and Atlantic Wolffish, and lowest between Northern and Atlantic Wolffish. Wolffish species differed significantly with respect to relative proportions of nine prey groups, and percent contribution of benthic and piscivorous prey. Northern Wolffish were described as "fish specialists" (piscivores), Spotted Wolffish as "echinoderm specialists" (benthivores), and Atlantic Wolffish as "mollusc specialists" (benthivores). This study addressed the recommended research pertaining to life history and ecosystem interactions, which fulfill objectives of the wolffish Recovery Strategy.

Morphometrics/Meristics

Northern Wolffish in NL waters appeared to comprise at least two distinguishable groups: a southern group centered on the northern and southeastern Grand Bank (Div. 3LN), and another smaller group scattered over much of the Northeast Newfoundland and Labrador shelves (Div. 2J3K). Atlantic Wolffish in NL waters also seemed to comprise two distinguishable groups: one centered on the southern Labrador shelf (Div. 2J), and another group centered on the southwest Grand Bank (Div. 3O). Atlantic Wolffish in Div. 3KLN and Subdiv. 3Ps were neither morphometrically nor meristically distinguishable from the other two groups. This research addressed population structure only in NL waters; similar studies have not been conducted in other locations.

Dissolved oxygen (DO)

In the Gulf of St. Lawrence (GSL), DO levels where some wolffish are found were shown to reduce growth rates of Spotted Wolffish in laboratory studies. At 8°C, Spotted Wolffish (150 g) from the northern GSL, raised below 70% saturation, were smaller than those raised in normoxic (normal) conditions, and their specific growth rate was proportional to DO. Reduced growth rate in hypoxia was accompanied by reduced food consumption, as well as a protracted period of increased oxygen consumption at 40% saturation. It appeared that hypoxia slowed digestion, and thus food consumption by unit time.

Hypoxia tolerance of Spotted Wolffish at 8°C, as measured by critical oxygen level (DO level at which fish cannot sustain its standard metabolic rate), is 17% saturation in 2 kg adults, and approximately 30% in 0.8 kg juveniles.

Spotted Wolffish distribution in the northern GSL suggested that they avoid the most hypoxic

zones; as demonstrated by their reduced occurrence in persistently hypoxic waters deeper than 175-200 m. Some individuals of all three wolffish species are exposed to DO levels below 50% saturation in the GSL. Growth potential of these fish is expected to be lower than for individuals in normoxic water, but there are no data on growth rate of wild Spotted Wolffish living at different DO levels. The potential impact of DO on gonad maturation and fertility has also not been studied. DO could also reduce wolffish egg development and hatching success; as found for Greenland Halibut (*Reinhardtius hippoglossoides*) eggs (Mejri et al. 2012). This study addressed recommended research pertaining to life history, habitat characteristics, and impacts of human activities, which fulfill objectives of the wolffish Recovery Strategy.

ASSESSMENT AND ANALYSIS

Distribution and Abundance

Central and Arctic

The three wolffish species are found in NAFO Subarea (SA) 0. However, abundances are low, and no directed fishery has ever occurred. Research surveys conducted by DFO in 1978-2010 caught Northern, Spotted, and Atlantic Wolffish in SA 0, but close to the boundaries of SA 1 (Greenland waters) and Div. 2G; possibly reflecting extensions of stocks from one or both of these areas (Fig. 2). Catches of Northern and Spotted Wolffish were limited to southern areas in Div. 0A, but occurred throughout Div. 0B. Spotted Wolffish were also caught in Div. 2G and Hudson Strait, but catches of Northern Wolffish were very limited in Hudson Strait, and none were caught in Div. 2G. Atlantic Wolffish were caught in research surveys in Div. 0B, Div. 2G, and Hudson Strait. Northern Wolffish were caught in 200-1100 m depths, Spotted Wolffish were caught in 200-700 m, and Atlantic Wolffish were caught in 200-500 m.

Area of occupancy (AO) for each species increased since 2006, because the research survey was expanded into Hudson Strait and Div. 2G in that year. AO values in SA 0 were essentially unchanged.

Newfoundland and Labrador

Information on the resource status of wolffish in NL waters were limited to data collected during annual DFO spring and fall research surveys. In 1994-1995, groundfish catchability changed; due to a change in standard survey gear from an Engel trawl to a Campelen shrimp trawl. Although comparative tows were conducted, there are no conversion factors for wolffish species.

All three wolffish species continue to show their highest densities and cover their largest areas on the northeast Newfoundland and southern Labrador shelves. An area centered north of the Grand Bank constitutes the most persistent concentrations of Northern Wolffish and Spotted Wolffish in the Northwest Atlantic; while an area of persistent concentration for Atlantic Wolffish is on the southern Grand Bank.

Mean catch per tow for Northern Wolffish was highest in Div. 2J3K at the onset of DFO fall surveys (1977); as compared to fall and spring indices on the Grand Bank (Div. 3LNO), and the spring index in Subdiv. 3Ps (Fig. 3). In recent years, there has been a very gradual increase in catch rates during spring surveys in Div. 3LNO. A very slight increase was also seen over similar time periods during fall surveys in Div. 2J3K and Div. 3LNO. In Subdiv. 3Ps, where Northern Wolffish were rarely caught, catch rates appeared lower, but less intermittent, in recent years.

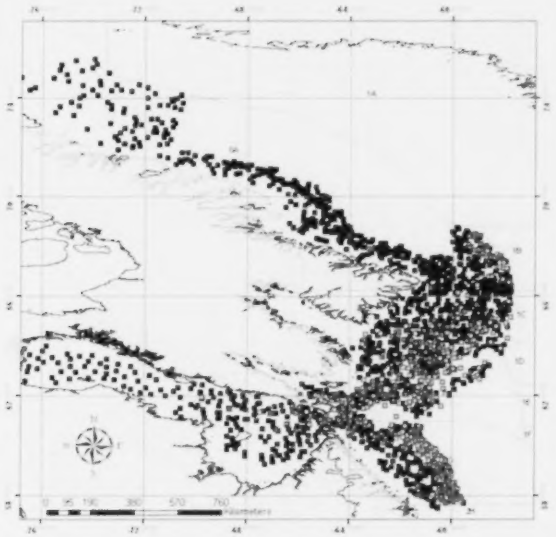

Figure 2. Locations of Northern (blue), Spotted (red), and Atlantic Wolffish (green) catches in research survey trawls (black squares indicate trawls without wolffish) in NAFO Subarea 0, Div. 2G, and Hudson Strait in 1978-2010.

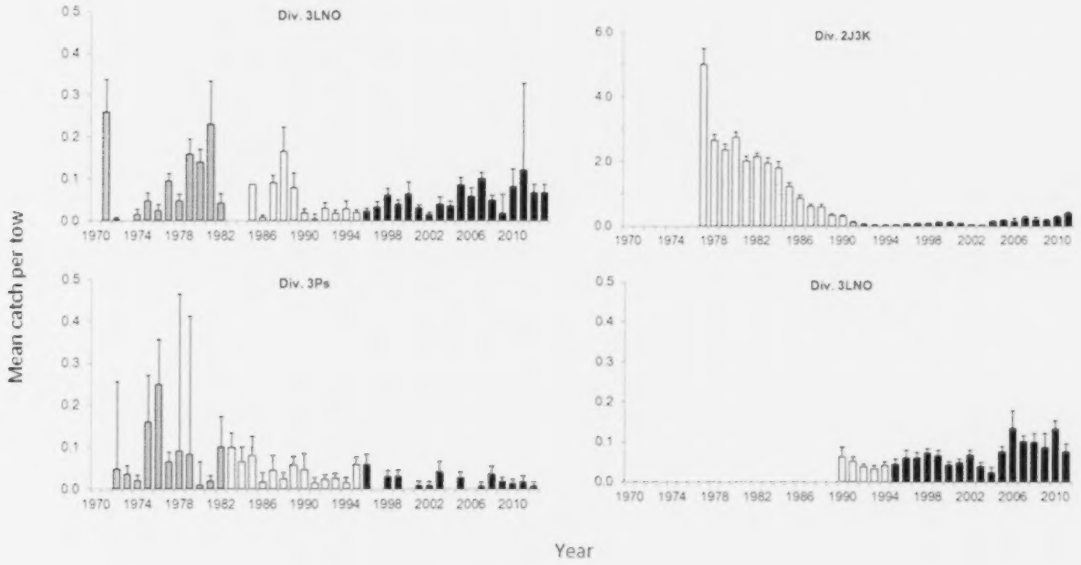

Figure 3. Abundance indices (mean catch per tow) for Northern Wolffish in Div. 2J3K, Div. 3LNO, and Subdiv. 3Ps during spring (left column) and fall (right column) research surveys.

Historically, trends in Spotted Wolffish abundance indices were highest in fall for Div. 2J3K during the late 1970s when DFO surveys began; but declined steadily through the 1980s (Fig. 4). In recent years, catch rates of this species were generally increasing during fall surveys in Div. 2J3K and Div. 3LNO. However, following a general increase in Div. 3LNO over 1995-2006, catches in spring surveys, have declined. The abundance index fluctuated without trend in Subdiv. 3Ps throughout this survey time series.

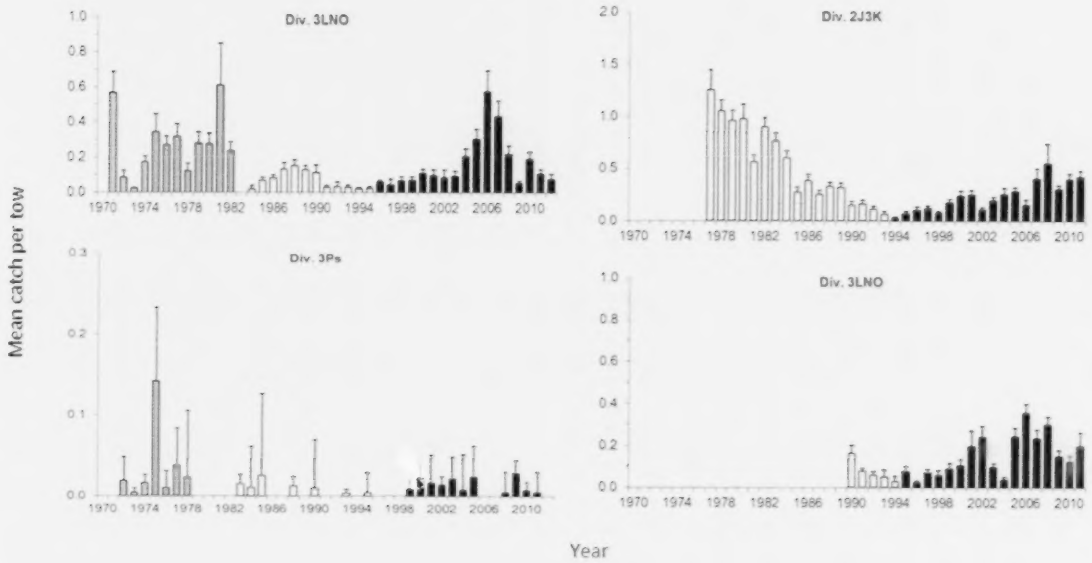

Figure 4. Abundance indices (mean catch per tow) for Spotted Wolffish in Div. 2J3K, Div. 3LNO, and Subdiv. 3Ps during spring (left column) and fall (right column) research surveys.

For Atlantic Wolffish, catch rates in recent years have been relatively stable in both spring and fall surveys (Fig. 5).

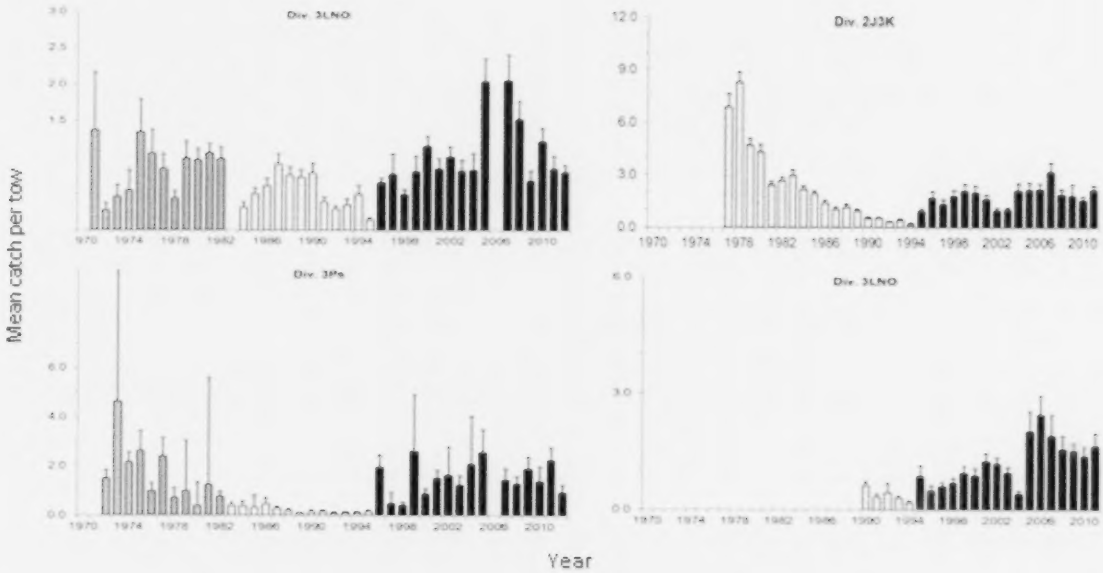

Figure 5. Abundance indices (mean catch per tow) for Atlantic Wolffish in Div. 2J3K, Div. 3LNO, and Subdiv. 3Ps from spring (left column) and fall (right column) research surveys.

For Northern and Spotted Wolffish, AO increased in Div. 2J3K over the past fifteen years; while remaining stable in Div. 3LNO (Fig. 6; Fig. 7). Area occupied by Atlantic Wolffish generally remained stable over the last 15-20 years (Fig. 8).

Figure 6. Area of occupancy for Northern Wolffish in Div. 2J3K and Div. 3LNO using spring (upright triangle) and fall (full and open circles) research survey data.

Figure 7. Area of occupancy for Spotted Wolffish in Div. 2J3K and Div. 3LNO using spring (upright triangle) and fall (full and open circles) research survey data.

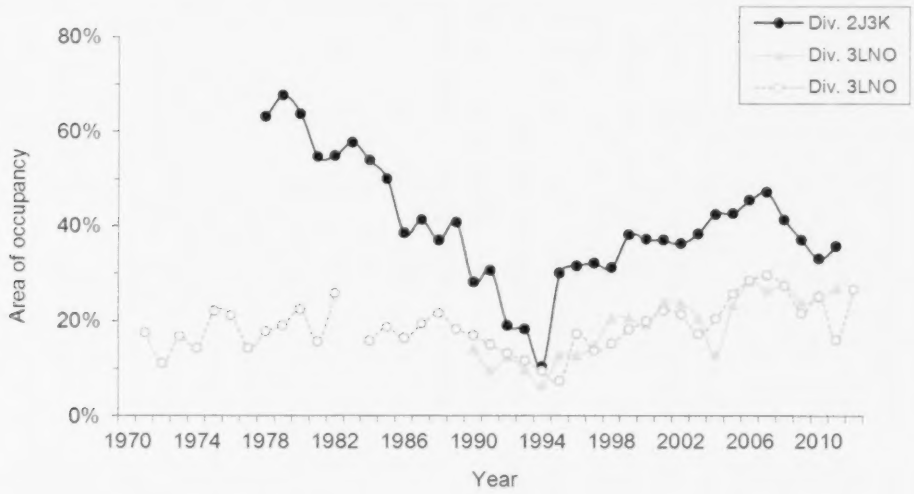

Figure 8. Area of occupancy for Atlantic Wolffish in Div. 2J3K and Div. 3LNO using spring (upright triangle) and fall (full and open circles) research survey data.

Gulf of St. Lawrence (GSL)

Distribution of the three species of wolffish in the northern (Div. 4RS) and southern (Div. 4T; excluding GSL Estuary) Gulf of St. Lawrence was described by Dutil et al. (2011) using data from several sources: annual DFO research surveys, annual stratified surveys from the mobile gear Sentinel Fishery, and annual surveys from the fixed gear Sentinel Fishery. Survey data from Research Vessel (RV) *Alfred Needler* (1990–2003) and Canadian Coast Guard Ship (CCGS) *Teleost* (2004–2012) were utilized to generate abundance indices and area of occupancy. For the northern GSL, different survey vessels and gear were used prior to 1990, and another vessel and gear change took place in 2004. For the latter, a conversion factor exists only for Atlantic Wolffish (Bourdages et al. 2007).

Northern Wolffish have never been abundant in the GSL during 1978-2012. It was virtually absent from the southern GSL; except for a few catches on slopes of the Laurentian Channel. Most individuals were captured on slopes or on the shelf off of the southwest coast of Newfoundland. Even though less rare than Northern Wolffish, Spotted Wolffish were also virtually absent from the southern GSL in 1978-2008. Most catches were recorded in the northeastern part of the GSL, on slopes of the Esquiman Channel, and on the shelf off of the Newfoundland west coast. Atlantic Wolffish were more widespread in the GSL, except in the Estuary (where it is known to occur, but has never been captured in research surveys). This species was most abundant on upper slopes of deep channels and on the shelves; especially the shelf off of Newfoundland's west coast. Spotted and Atlantic Wolffish showed a large degree of spatial overlap; with Atlantic Wolffish occurring more closely to coastlines, and avoiding deep channels.

Northern Wolffish were caught only occasionally during summer surveys of the northern GSL (Div. 4RS); thus, no trend was apparent (Fig. 9). Northern Wolffish were not observed in the southern GSL.

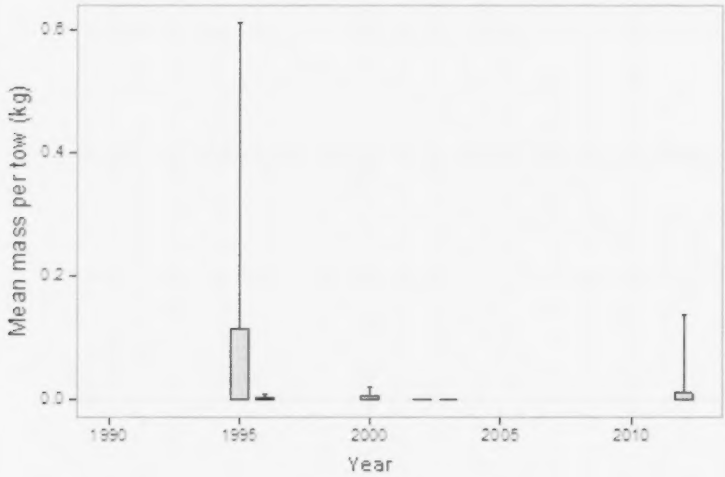

Figure 9. Abundance indices (average mass per tow) for Northern Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during summer research surveys. Error bars are 95% confidence intervals.

Mean abundance of Spotted Wolffish in Div. 4RS (northern GSL) was particularly low from 1990-1996, with a small trend toward higher abundance afterwards; albeit only about 0.25 kg per tow (Fig. 10).

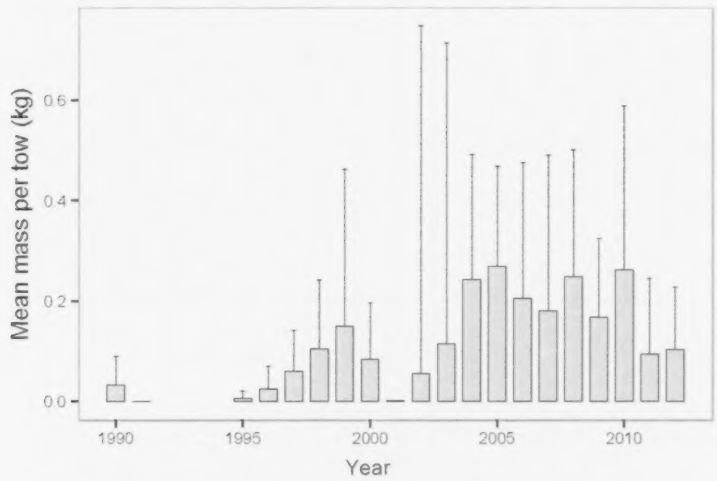

Figure 10. Abundance indices (average mass per tow) for Spotted Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during summer research surveys. Error bars are upper 95% confidence intervals.

Atlantic Wolffish was slightly more abundant at approximately 0.5 kg per tow in Div. 4RS (northern GSL; Fig. 11). No trend was visible over 1990-2012. This is the only wolffish species caught in research surveys of the southern GSL in Div. 4T (Fig. 12). Abundance indices were low over 1970-2012; although 1989–1997 were characterized by higher abundances.

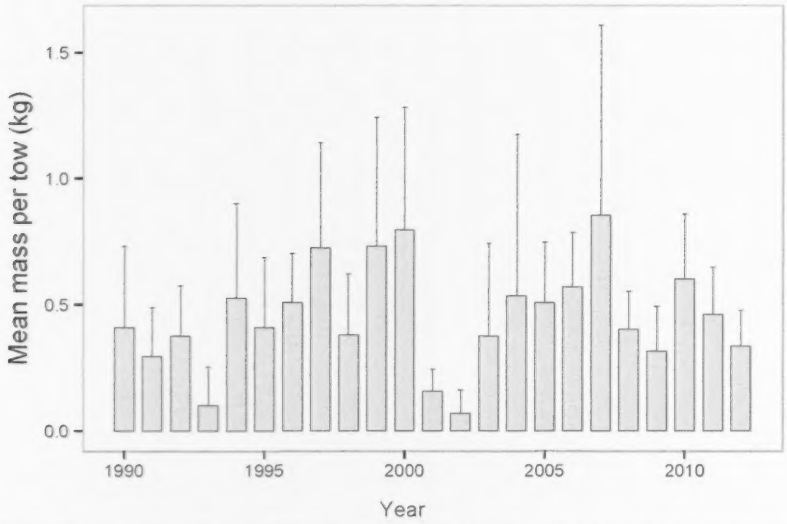

Figure 11. Abundance indices (average mass per tow) for Atlantic Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during summer research surveys. Error bars are upper 95% confidence intervals.

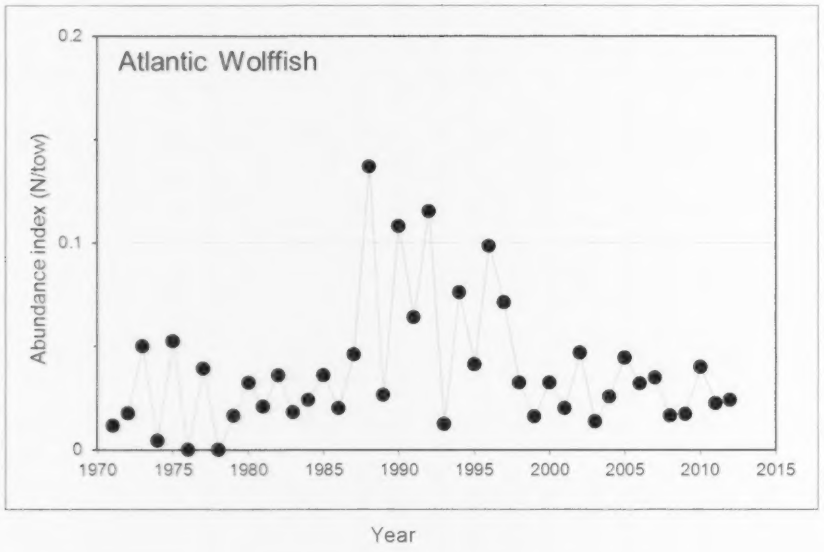

Figure 12. Abundance indices (average number per tow) for Atlantic Wolffish in Div. 4T (southern GSL; excluding the Estuary).

Northern Wolffish has always occupied a very small proportion of the northern GSL, but it became even rarer at the end of the 1980s: found in only four sets during 1990-2012 (Fig. 13). It is unclear whether the larger area of occupancy prior to 1990 represents a more abundant population, or a change in survey design and gear.

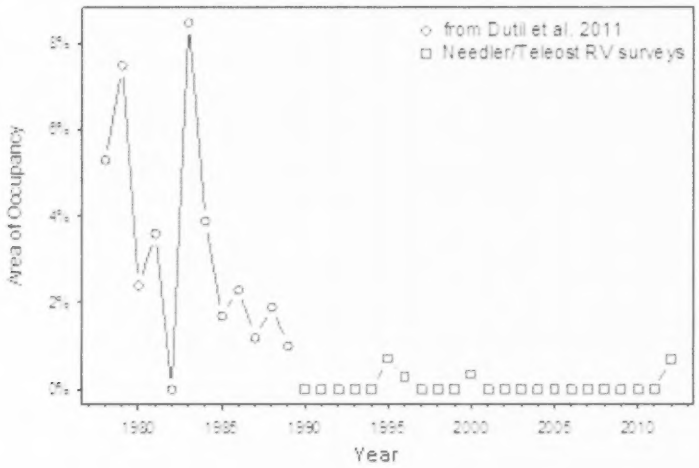

Figure 13. Area of occupancy for Northern Wolffish in Div. 4RS (northern Gulf of St. Lawrence).

In 1978-2012, Spotted Wolffish occupied an average of 4.1% (±3.2 SD) of the surveyed area of the northern GSL (Fig. 14); suggesting a reduction in AO. This coincides with the collapse of other demersal fishes (e.g., Atlantic Cod *Gadus morhua*) in the northern GSL during the early 1990s (Fréchet et al. 2009). In recent years, there appeared to be a return to an AO typical of the 1980s (5–6%). Changes in survey vessels and gear may have caused some of these differences, but data covering this entire period (i.e., indicating very low AO and the apparent beginning of recovery) were collected with the same vessel and gear (RV *Alfred Needler*, 1990-2003).

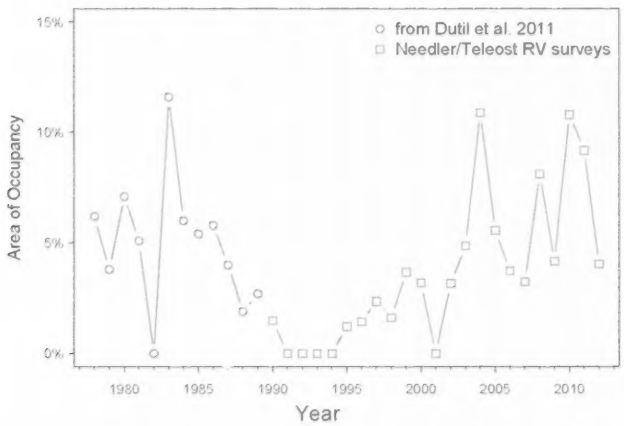

Figure 14. Area of occupancy for Spotted Wolffish in Div. 4RS (northern Gulf of St. Lawrence).

AO for Atlantic Wolffish was 15.8% on average (±5.4 SD; Fig. 15). It was lowest in 1990-1995 but, by the late 1990s, returned to values similar to those observed in 1978-1989.

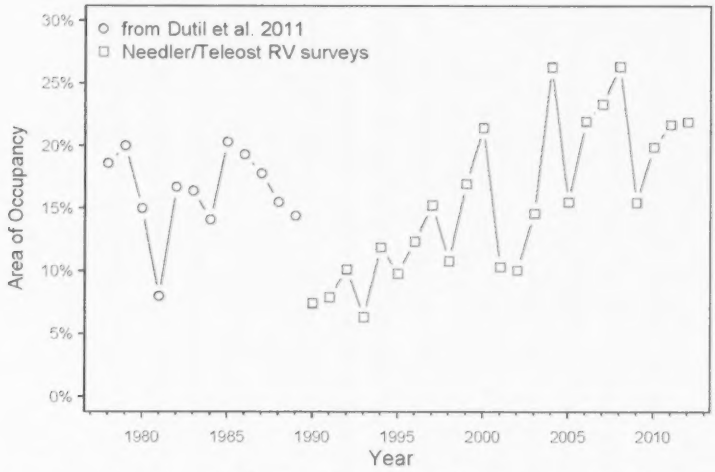

Figure 15. Area of occupancy for Atlantic Wolffish in Div. 4RS (northern Gulf of St. Lawrence).

Maritimes

The DFO summer survey has been conducted annually on the Scotian Shelf (Div. 4VWX) since 1970, using a stratified random design based on depth and geographic area. In 1970-1981, this survey was conducted using a Yankee 36 trawl, and was replaced in 1982 by the Western IIA as standard survey gear. No conversion factors were applied to these data.

The composite distribution pattern revealed two primary areas of wolffish concentration: on the eastern Scotian Shelf (including Subdiv. 4Vn), and on the western Scotian Shelf (Div. 4X; primarily Brown's Bank).

Mean number per tow for Atlantic Wolffish (all lengths) in Maritimes waters declined since 1990 (Fig. 16). Estimates for the past four years remained below the long term average. Wolffish from these waters were the only specimens for which length data were presented. Overall abundance trends for mature individuals (>53 cm total length) on the Scotian Shelf (Div. 4VWX) continued to be very low; while 2011 and 2012 survey indices for the immature group (1-53 cm TL) remained below average (Fig. 17). AO for Atlantic Wolffish exhibited a steady decline: from approximately 60,000 km^2 to about 10,000 km^2 (in 2012; Fig. 18).

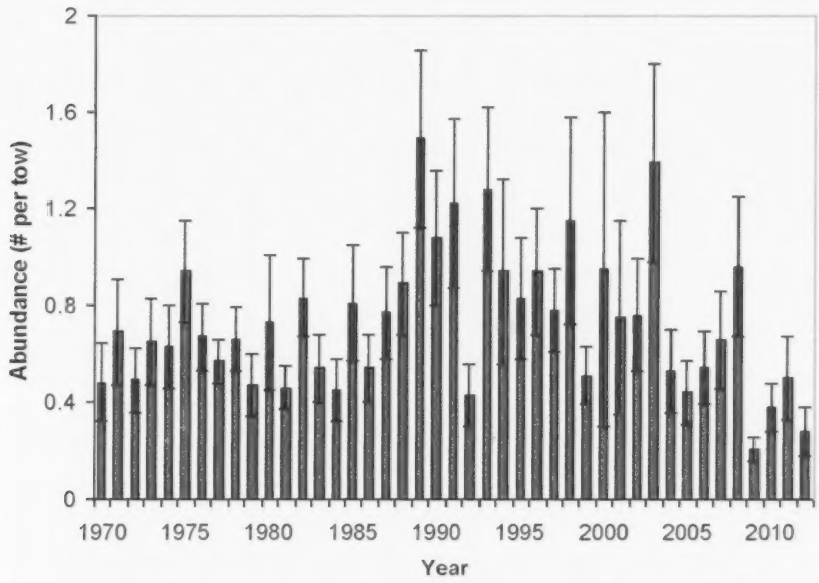

Figure 16. Abundance indices (number per tow) for Atlantic Wolffish (all lengths) in Div. 4VWX and a small area of Div. 5Y during summer research surveys.

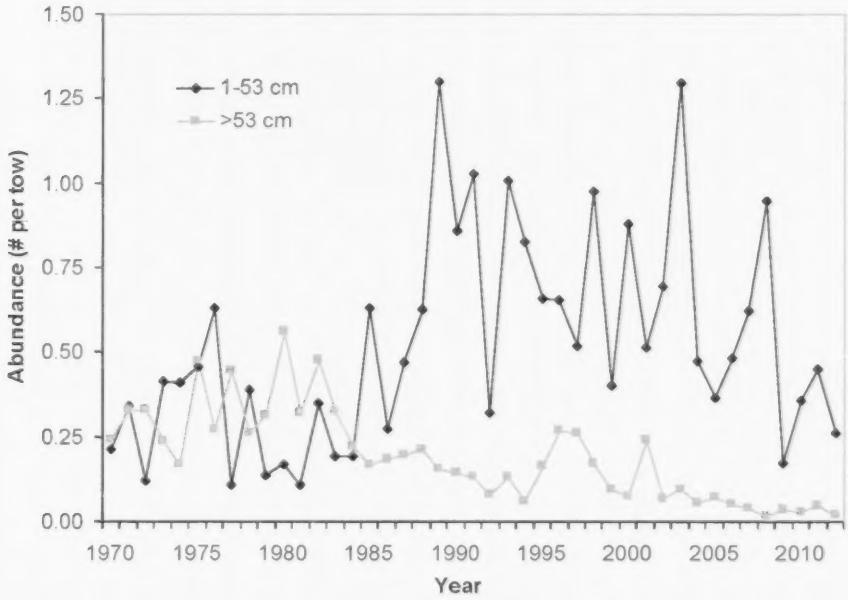

Figure 17. Abundance indices (number per tow) for Atlantic Wolffish (1-53 cm TL; >53 cm) in Div. 4VWX and a small area of Div. 5Y during the annual summer research survey.

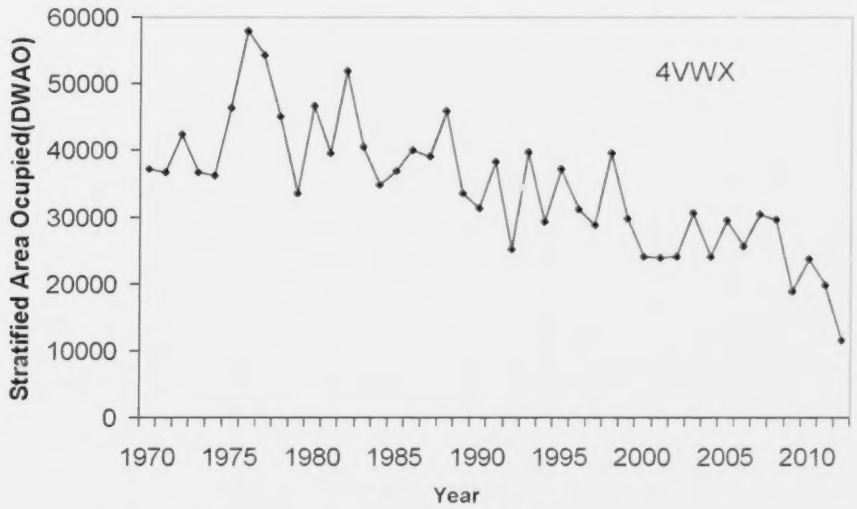

Figure 18. Area of occupancy for Atlantic Wolffish in Div. 4VWX during the annual summer research survey.

Northern Wolffish were restricted primarily to the eastern Scotian Shelf, including Div. 4V. There were also records of this species on the outer edge of the Scotian Shelf in Div. 4WX. Spotted Wolffish were restricted to Subdiv. 4Vn and 4Vs; with a couple of records on the eastern edge of Div. 4W. There were no records of either species in the 2011 or 2012 research surveys (Fig. 19; Fig. 20).

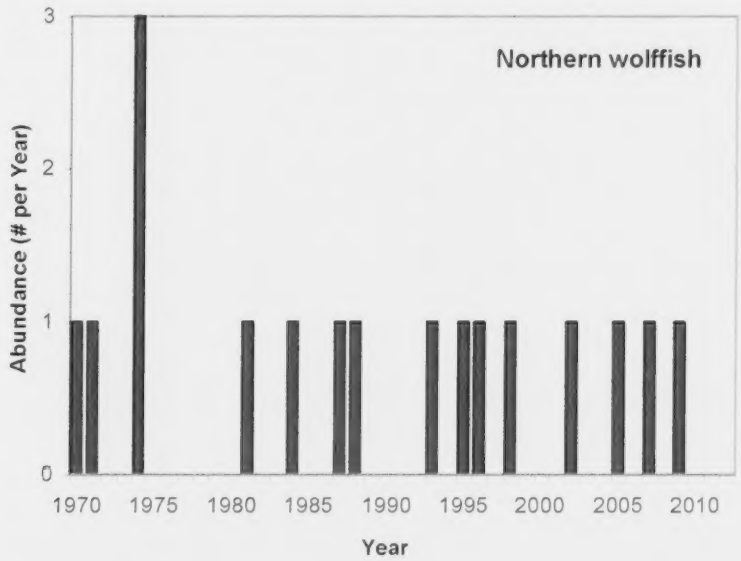

Figure 19. Total number of Northern Wolffish caught in Div. 4VWX5Y during the annual summer research survey.

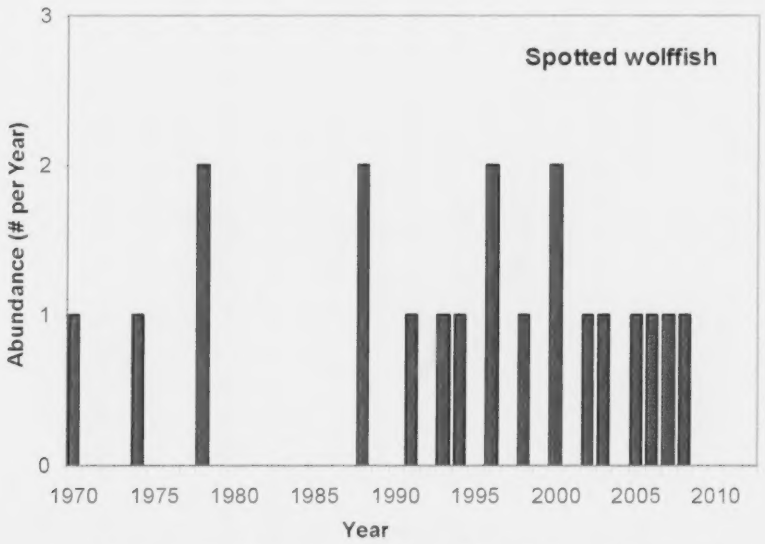

Figure 20. Total number of Spotted Wolffish caught in Div. 4VWX5Y during the annual summer research survey.

Biological Reference Points

Under the DFO Precautionary Approach (PA) framework, the Critical, Cautious, and Healthy stock status zones are defined by the Limit Reference Point (LRP) and the Upper Stock Reference Point (USR). Where there is insufficient information to determine stock biomass from an analytical model, an empirical approach can be used to identify proxies for the biomass at the Maximum Sustainable Yield (B_{MSY}), which can then be used for defining empirical Biological Reference Points. These default reference points are 40% B_{MSY} (LRP), and 80% B_{MSY} (USR). For example, a B_{MSY} proxy based on Div. 2J3K fall survey data (from which LRP and USR were derived) was used to demonstrate the methodology. While the merit of this methodology is recognized, further investigation is highly recommended before any derived reference points can be accepted as realistically applicable.

Fishery Removals and Mortality

Landings

Commercial fisheries data for wolffish are unspeciated (except for Canadian Fisheries Observers' data): all three species are recorded by fishers as "Catfish" or "wolffish-unspecified". Canadian fisheries targeting wolffish in Canada's Exclusive Economic Zone (EEZ) are very limited; thus wolfish landings are almost always recorded as bycatch in fisheries targeting other commercial species.

Reported landings of wolffish peaked at 12,000 tons in 1971 throughout the entire Canadian zone of interest (NAFO Div. 0AB, 2GH, 2J3K, 3LNO, 3P, 4RST, 4VWX); then subsequently declined (Fig. 21). Since 2003, with the passage of Canada's SARA, landings have consisted solely of Atlantic Wolffish due to mandatory release of both Northern Wolffish and Spotted Wolffish (Table 1). It is thus assumed that fishing mortality of Northern and Spotted Wolffish has been reduced in Canada's EEZ.

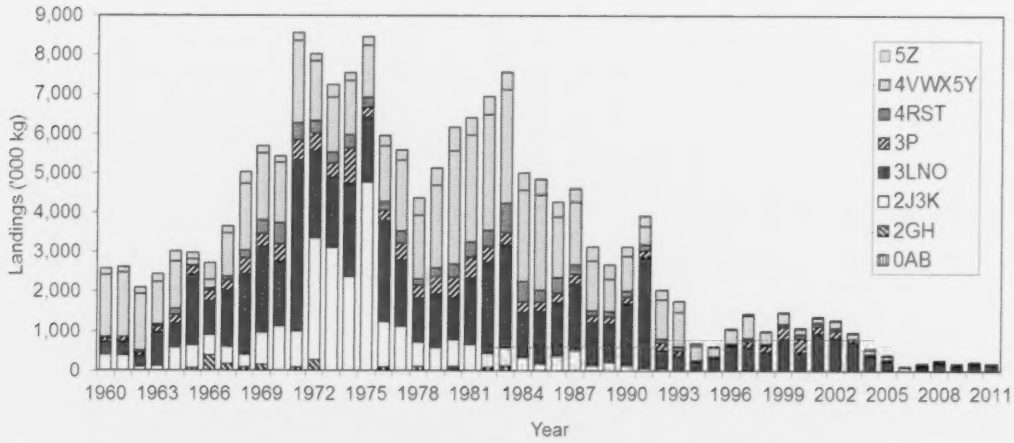

Figure 21. Reported landings of unspeciated wolffish in 1960-2011 from NAFO, ZIF, and MARFIS databases. Data do not include discards at sea.

Table 1. Reported landings ('000 kg)[1] of unspecified wolffish in 2002-11. Data do not include discards at sea.

Division	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0AB										
2GH										
2J3KL	26	5								
3LNO	805	725	384	246	29	94	198	115	155	162
3Ps	169	69	39	36	19	18	22	26	13	5
4RST	97	14	7	6	6	10	18	15	26	6
4VWX5Y	166	141	120	93	62	50	21	10	9	6
5Z	7	7	4	13	7	4	2	1	1	1

[1]Based on NAFO STATLANT 21A, 4 December 2012, except for 4VWX5Y based on ZIF (2002) and MARFIS, 31 January 2013

Based on the condition of wolffish bycatch when released in NL commercial fisheries, SARA logbook data from fishers aboard >35 foot commercial vessels fishing in Canada's EEZ indicated that a high percentage of wolffish were released alive in 2005-2010 (Table 2). It should be noted that live release does not guarantee post-release survival; although survival prospects are improved with careful handling and quick release at sea. Reasons for apparent decreases in the percent alive upon release for Northern Wolffish and Atlantic Wolffish since 2010 are unknown.

Table 2. Condition of wolffish (numbers) when released at-sea by NL fishers in 2004-2012. Data as of 14 December 2012.

		Year								
Species	Condition	2004	2005	2006	2007	2008	2009	2010	2011	2012
Wolffish, Northern	Alive	22	307	560	347	330	594	788	555	344
	Dead	52	117	62	190	22	68	164	344	334
	% Alive	30%	72%	90%	65%	94%	90%	83%	62%	51%
Wolffish, Spotted	Alive	62	957	865	902	1039	1941	1842	1901	1038
	Dead	3	83	21	38	43	34	117	145	164
	% Alive	95%	92%	98%	96%	96%	98%	94%	93%	86%
Wolffish, Atlantic	Alive		121	114	258	231	343	331	195	183
	Dead		8	9	13	27	71	194	310	250
	% Alive		94%	93%	95%	90%	83%	63%	39%	42%

Sources of Uncertainty

There is a paucity of data concerning wolffish in Canadian waters. Information regarding age and growth, reproduction, mortality, movements, and stock structure is not currently available.

Recent research was conducted to address objectives of the Recovery Strategy. However, judicious interpretation of the results is required for the dietary and morphometric/meristic studies. Data for dietary analyses were pooled across years, precluding determination of temporal trends. In the absence of stable isotope analysis, results from dietary studies may be biased due to differential rates of prey digestion. These data were also obtained from a limited portion of the species' range. Analyses of morphometrics and meristics were also conducted using data obtained from a limited portion of the species' range; results may thus not apply to the entire range of each wolffish species.

Hypoxia may have affected growth rate, reproductive rate, and egg survival for Spotted Wolffish in the Gulf of St. Lawrence. A comparison of size at age inside and outside the Gulf of St. Lawrence would be required to determine if hypoxia has done so for this stock.

Lack of speciated commercial wolffish landings (except for Canadian Fisheries Observers' data), unreported discards at sea, and misreporting of fishing locations and/ or species caught, place substantial restrictions on the evaluation of wolffish mortality in commercial fisheries.

In commercial SARA logbooks, wolffish condition (alive *versus* dead) is poorly defined for fishers. Furthermore, wolffish survival after capture is probably affected by physical factors, such as internal physiological stress due to encountering significant differences in water temperature during fishing gear retrieval, and wolffish handling time by fishers aboard vessel. Live release also does not guarantee post-release survival. Although completion of SARA logbooks is a condition of some commercial fishing licences for Canadian waters, these data do not represent all wolffish fishing mortalities, and do not reflect such mortality that regularly occurs outside Canada's 200-mile limit.

CONCLUSIONS

Research vessel estimates of abundance and biomass in the surveyed areas remain low relative to historic levels. Furthermore, areas historically occupied by these stocks have reduced. In recent years, there was an indication of increased abundance in some historic areas.

Wolffish landings have historically been reported primarily as bycatch. Reported landings are currently low relative to historic levels, and mandatory release under SARA is required for both Northern Wolffish and Spotted Wolffish caught in Canadian waters.

SOURCES OF INFORMATION

This Science Advisory Report is from the January 23-24, 2013 assessment of Northern, Spotted, and Atlantic Wolffish related to population status, life history, and habitat. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule.

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